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Influence of Corn Kernel Traits on Digestibility and Ruminal Fermentation

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Summary

A metabolism trial was conducted to determine the influence of corn kernel traits on digestibility. The seven hybrids used in this study were the same as those fed in a feedlot performance trial where kernel traits were correlated to feed efficiency. These hybrids were selected to represent a range within and among kernel traits. There were no differences in total tract digestibility for hybrids that have softer endosperm. Ruminal pH parameters and intake behavior were not found to be different for animals in the metabolism trial. However, differences did exist among hybrids for volatile fatty acid production. VFA production over time was similar for all treatments with a peak in total VFA concentrations five to seven hours after feeding.

Introduction

Corn is the primary ingredient in feedlot diets due to its high energy value and subsequent animal performance. Cattle consuming starch from corn hybrids which are more rapidly degraded in the rumen are more efficient than those fed corn which is more slowly degraded (*Nebraska Beef Report, 2004* pp. 54). The interaction of many physical and chemical properties in the kernel can contribute to how starch is utilized. A softer endosperm kernel is generally thought to have more enzyme accessible space between the starch molecules. This increases the ability of bacteria to attach and degrade kernels to a greater extent.

Seven corn hybrids varying in chemical and physical properties were fed in a performance study to determine the impact of those properties on finishing cattle performance (Nebraska Beef Report, 2004 pp. 54). Larger, softer kernels were found to be significantly correlated to improved feed efficiencies when fed as dry-rolled corn. The results from the performance study suggest that kernel traits have an impact on starch utilization by feedlot cattle. Stenvert hardness tests from the previous study showed that hybrid 6 has the softest kernel traits followed by 1, 7, 2, 4, 5, and 3. Using these data, our hypothesis was that softer kernels are more digestible and total volatile fatty acid production would be greater for those kernels. The objective of this research was to examine total-tract nutrient digestibility, volatile fatty acid production, and monitor ruminal fermentation patterns of the same hybrids fed in the performance study.

Procedure

Seven ruminally cannulated cross-bred yearling heifers (avg. BW = 1130 lb) were used in a 7x7 Latin square designed experiment to determine the digestibility of seven hybrids varying in chemical and physical properties. The seven hybrids consisted of Golden Harvest H- 9164Bt (1), H-9235Bt/RR (2), H-9230Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7). All diets among treatment groups were identical except for the hybrid fed as dry-rolled corn. The final diet consisted of 68.5% dry-rolled corn, 20.0% wet corn gluten feed, 7.5% alfalfa, and 4.0% supplement. Heifers were fed for ad libitum intake once daily at 0700. Periods were 14 days in length with a 9-day adaptation to the diet and a 5-day collection period. Heifers were individually fed in pens on days 1-8 during the adaption and moved into stanchions for the collection period on day 9.

Individual feed bunks suspended from load cells were used to monitor feed intake patterns. Feed intake measurements (day 10 to 14) included DMI, number of meals per day, average meal size, total time spent eating, and average meal length. Continuous pH measurements were collected using submersible pH electrodes placed into the rumen during the collection period. Probes were suspended in a stationary position 4-6 inches above the ventral floor of the rumen prior to the collection period. Intake and pH measurements were recorded every six seconds and averaged for each minute.

Chromic oxide was used as an indigestible marker for estimating fecal output. Boluses were given via rumen cannula twice daily at 0700 and 1900 with each dose containing 7.5 grams chromic oxide. Fecal grab samples were collected three times daily on days 10 though 14 at 0, 6, and 12 hours post-feeding. Feed ingredients, feed refusals, and fecal samples were freeze-dried and analyzed to calculate nutrient digestibility. Ruminal fluid samples were collected on day 14 of each period prior to feeding, and every two hours post-feeding for a twelve-hour period to determine volatile fatty acid production.

Table 1. Effect of corn hybrid on ruminal pH.

	Hybrid[a]								
Parameter	1	2	3	4	5	6	7	SEM	*P*-value
Average pH	5.53	5.49	5.68	5.48	5.47	5.62	5.46	0.18	0.32
Maximum pH	6.28	6.30	6.48	6.21	6.17	6.32	6.07	0.12	0.36
Minimum pH	5.05	5.02	5.10	5.05	5.08	5.15	5.03	0.64	0.58
pH change	1.19	1.28	1.37	1.13	1.09	1.16	1.06	0.12	0.46
pH variance	0.28	0.25	0.26	0.23	0.22	0.26	0.21	0.02	0.12
Time < 5.6	913	899	630	935	954	761	1075	128	0.19
Area < 5.6	288	279	186	269	306	195	358	68	0.56

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).

Table 2. Effect of corn hybrid on total tract digestibility.

	Hybrid[a]								
Item	1	2	3	4	5	6	7	SEM	*P*-value
Dry Matter									
Intake, lb/day	20.9	21.3	22.5	20.8	21.5	21.5	22.3	1.41	0.91
Digestibility, %	78.4	76.1	74.6	79.3	78.0	77.8	75.1	2.13	0.19
Organic Matter									
Intake, lb/day	19.7	20.0	21.0	19.5	20.1	20.2	20.8	1.31	0.93
Digestibility, %	79.3	77.7	76.1	80.1	79.0	78.3	74.9	2.89	0.46
Starch									
Intake, lb/day	9.7[c]	11.9[de]	12.2[de]	11.2[cd]	11.5[de]	12.5[de]	13.1[e]	0.73	0.02
Digestibility, %	94.5	94.8	94.9	95.5	95.5	95.2	95.3	0.64	0.58

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b] F-test statistic for the effect of hybrid.
[c,d,e]Means within a row with unlike superscripts differ (*P* <0.05).

Results

There were no differences in measured intake patterns among treatments. Heifers consumed an average of 3.4 lb of dry matter with 7.2 meals consumed per day. Total time spent eating was 600 minutes with each meal averaging 92 minutes (data not shown). Differences were found in starch intake among treatments with animals consuming the least amount of starch with hybrid 7 and the most with hybrid 1. These differences are due to the percent starch of the hybrid (63.8% and 80.3%, respectively).

Average pH, maximum pH, minimum pH, and pH change along with time and area below 5.6 are shown in Table 1. Ruminal pH measurements were not influenced by grain hybrid; however, some numerical differences in average pH were evident. Lower ruminal pH results would support a greater rate and extent of starch digestion, but could have been mediated in this study due to the inclusion of WCGF in the diet.

Total tract DM, OM and starch digestibilities were similar among treatments (Table 2). Dry matter, organic matter, and starch digestibilities averaged 77.1%, 77.9% and 95.1%, respectively. These results could be due to the intakes observed in the metabolism heifers. Intakes were lower as a percentage of body weight for the metabolism heifers (1.9%) compared to the finishing steers (2.3%). The lower intakes could have slowed the rate of passage of feed particles from the rumen and therefore increased the extent of degradation of starch from hybrids that have harder kernel characteristics.

Rumen fluid analysis indicates there were differences (*P* < 0.01) among hybrids for VFA production. Cattle consuming hybrid 3, the least efficient in the feedlot study, had the lowest propionate and total VFA concentrations along with a higher A:P ratio. Although starch digestion was not found to be different among hybrids, higher propionate and total VFA concentrations would suggest that the rate of starch fermentation plays a critical role in animals consuming more total DM, as discussed earlier. Interestingly, propionate production was not significantly correlated to F:G but was correlated to other physical measurements performed on the hybrids. The Stenvert time to grind was significantly correlated (r = -0.84) to propionate production. This would indicate that as the time

(Continued on next page)

Table 3. Effect of corn hybrid on VFA production.

	Hybrid[a]								
Item	1	2	3	4	5	6	7	SEM	*P*-value
Acetate, mM	41.9	43.8	44.2	41.8	44.1	44.6	42.6	2.9	0.53
Molar %	42.0^{c}	46.6^{de}	49.1^{e}	41.4^{c}	42.8^{cd}	44.6^{cd}	44.5^{cd}	1.8	<0.01
Propionate, mM	40.8^{c}	38.1^{c}	29.3^{d}	42.3^{c}	41.3^{c}	39.3^{c}	38.1^{c}	3.1	<0.01
Molar %	43.6^{c}	40.4^{cd}	33.7^{e}	42.2^{cd}	38.4^{cde}	38.6^{cde}	37.7^{de}	2.9	0.01
A:P	1.02^{cd}	1.29^{d}	1.67^{e}	0.97^{c}	1.25^{cd}	1.29^{cd}	1.29^{cd}	0.2	<0.01
Butyrate, mM	10.1	13.1	10.8	11.0	8.0	11.8	12.5	1.9	0.16
Total VFA, mM	97.7^{d}	94.6^{de}	89.7^{e}	100.1^{cd}	104.2^{c}	100.5^{cd}	98.9^{cd}	4.6	<0.01

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b]F-test statistic for the effect of hybrid.
[c,d,e]Means within a row with unlike superscripts differ ($P < 0.05$).

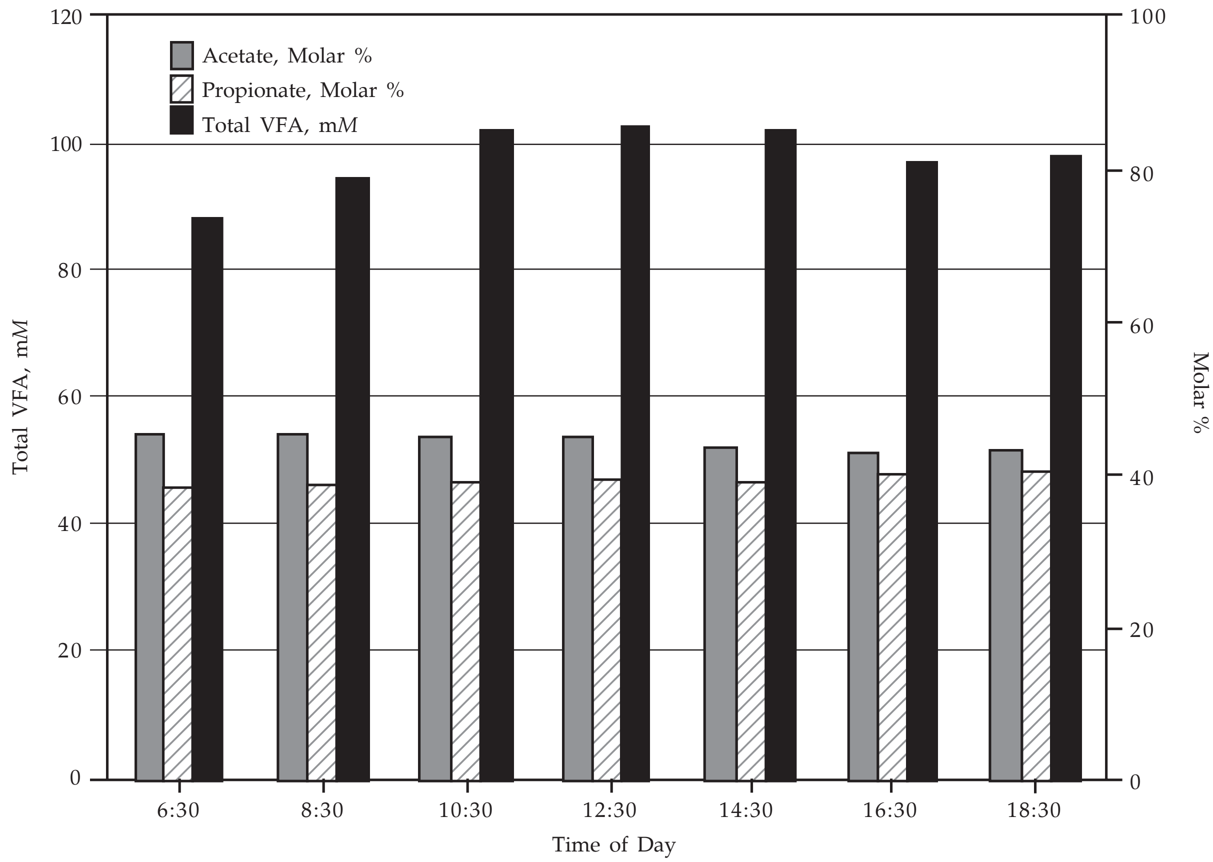

Figure 1. Schematic representing change over time across all treatments for total VFA concentration (m*M*) and molar proportions of acetate and propionate.

to grind harder kernels increases, propionate production decreases.

Because there were no interactions between hybrid and time of day, the main effects of time on VFA production are illustrated in Figure 1. Both acetate and propionate concentrations were lowest prior to feeding (0630) and increased throughout the sampling day with a peak production five to seven hours after feeding. These production patterns contributed to a peak in total VFA concentration five to seven hours after feeding. During this time, the propionate molar proportion increased from 38% to 40%, while the molar proportion of acetate decreased from 45% to 43%. The changes in acetate and propionate production across time reduced the A:P ratio from a high of 1.35 just prior to feeding to a low of 1.17 twelve hours post feeding.

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